THE DISTRIBUTION OF INTRODUCED SNAILS IN SOUTH AUSTRALIA

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INTRODUCTION

With the development of gardens and agriculture in South Australia has come the introduction of a variety of exotic terrestrial snails; some have settled unobtrusively and are seldom noticed, some have probably escaped notice completely and are yet to be found, but others have made themselves felt by their depredations in gardens and crops or by their countless numbers. Record has been made of species in South Australia on a number of different occasions (Verco, 1922, 1924; Cotton, 1954; Quick, 1952, 1953; Taylor, 1928) but no account has been given of their distribution in the State. In the following pages the introduced species and their present distribution will be considered.

SNAILS INTRODUCED INTO SOUTH AUSTRALIA

During the past hundred years, ten species of exotic snail are known to have become established in South Australia (table 1). Six of these do occur naturally in the British Isles but the ranges of all ten include the Mediterranean region. All species (except *Ferussacia*) are known (Pomeroy, 1966; Laws, unpublished) to have the ability to survive in a dormant state for several months, an ideal attribute for long range dispersal by man.

Times of arrival and establishment in South Australia are extremely difficult to ascertain. The earliest known records for these species in South Australia are given in table 2 but it is very likely that some, especially the smaller inconspicuous ones, were established for a considerable time before they were noted. The earliest recorded introduction is that of *Helix aspersa* which was brought to Adelaide before 1879 and liberated in the West Terrace cemetery in the hope that it would help in eradicating introduced slugs; it was also thought to have been brought in by Sir Samuel Way to provide food for aviary birds (Cotton, 1949). The British Isles would be the most likely place of origin of these importations. *Cochlicella ventrosa*, *Helicella stolismena* and *Ferussacia* (Section *Ferussacia*) occur naturally only in the Mediterranean region (including Spain and Southern France) and most probably came from that area. *H. neglecta* the second earliest recorded species, must have come from the Mediterranean region since the establishment of a colony in Kent in 1915 post-dates its introduction to South Australia. *Theba* occurs in the British Isles,

TABLE 1

Snails introduced into South Australia, their native range and other areas of introduction

Species	Native Distribution	Areas of Introduction	
		World	Australia
Ferussacia sp. (Section *Ferussacia*)	Mediterranean	—	—
Oxychilus alliarius (Miller)	British Isles, Europe, North Africa, Scandinavia	South Africa, U.S.A.	N.S.W.
Helicella virgata (da Costa)	British Isles, West Europe, Mediterranean	—	Victoria, Queensland
H. neglecta (Draparnaud)	South France, Mediterranean	British Isles (in Kent, 1915)	—
H. caperata (Montagu)	British Isles, Europe, East Mediterranean	—	Victoria, Tasmania
H. stolismena (Bourguinat)	Spain, South France	—	—
Helix aspersa (Müller)	British Isles, Europe, West Mediterranean to Black Sea	U.S.A., South Africa, New Zealand, Mexico, Chile, Argentina, Haiti	Victoria, Tasmania, Queensland, West Australia, New South Wales
Cochlicella acuta (Müller)	West and South West British Isles, South West Europe, Mediterranean	—	West Australia
C. ventrosa (Ferussac)	South France, Mediterranean	U.S.A., South Africa	Victoria, Tasmania
Theba pisana (Müller)	Spain, West France, Mediterranean, Local only in South West British Isles	California (now eradicated), Somaliland, South Africa	West Australia, Victoria

TABLE 2

Earliest authentic records of introduced species in South Australia

Species	Date	Locality	Reference
Ferussacia sp.	1953	Linden Park, Adelaide	Cotton, 1954
Oxychilus alliarius	(1935)	(Hove)	S.A.M. Coll.
	1962	Linden Park	S.A.M. Coll.
Helicella virgata	1920-21	Millicent	Verco, 1924 (as *Helix pisana*)
H. neglecta	1891	Leveus, Yorke Peninsula	Cox, in Taylor
H. caperata	1934	Robe	S.A.M. Coll.
H. stolismena	1912	Robe	S.A.M. Coll.
Helix aspersa	Before 1879	Adelaide	Cotton, 1949
Cochlicella acuta	1953	Minlaton, Yorke Peninsula	S.A.M. Coll.
C. ventrosa	1921	Mount Gambier	S.A.M. Coll.
Theba pisana	1928	Port Adelaide	Taylor, 1928

but locally and in the extreme South West and therefore most probably also came from the Mediterranean (Quick, 1953). Quick is of the opinion that *H. virgata* is also an introduction from that region since some specimens which he examined are much closer to Mediterranean forms than to British ones. There is thus evidence of Mediterranean origin for at least half of our introduced land snails. Similarities of climate would certainly favour the establishment of Mediterranean species in South Australia.

The most recent introductions are those of *Cochlicella acuta* and *Ferussacia* sp. *Oxychilus alliarius* also appeared in the Linden Park area in 1962 (Laws, in press); a small collection of three similar shells was made at Hove in 1935 but they cannot positively be assigned to this species.

THE DISTRIBUTION OF THE INTRODUCED SNAILS

The distribution of introduced land snails in South Australia is shown in fig. 1. Centres of establishment are on Yorke Peninsula, in the Adelaide area, and in the South-East of the State where, in each case, six species occur.

Helix aspersa, *Helicella virgata* and *Cochlicella ventrosa* occur widely throughout the agricultural regions of the State, although *H. aspersa* is confined to areas with summer watering. Apart from the localities of the earliest records, there is little information on the spread of *H. virgata* and *C. ventrosa* except that both have become established on Kangaroo Island within the last 15 years (H. M. Cooper, pers. comm.). *Helix aspersa* arrived there considerably earlier, but it has only recently been found on southern Yorke Peninsula probably having been introduced to Edithburgh within the past two years (M. Kenny, pers. comm.). *Helicella caperata* is restricted to the South-East and is also abundant in Victoria; *H. stolismena*, originally recorded from Robe in 1912, is now known to occur at Murray Bridge where it is locally abundant in an abandoned quarry along with *H. virgata*, *C. ventrosa* and the native snails *Elsothera murrayana* (Pfeiffer) and *Paralaoma stabilis* Iredale.

[*]*Oxychilus alliarius* and *Ferussacia* sp. are both recorded only from the Adelaide area. *Helicella neglecta* and *Cochlicella acuta* are restricted to Yorke Peninsula; a single collection of *H. neglecta* in the South Australian Museum does bear the locality label "Naracoorte" but this has not been confirmed.

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[*] *Oxychilus alliarius* has recently, June 1967, been found at Mount Gambier, after this paper had been set up and the figure on p. 486 reproduced. It has not been possible therefore to include this occurrence on this map.

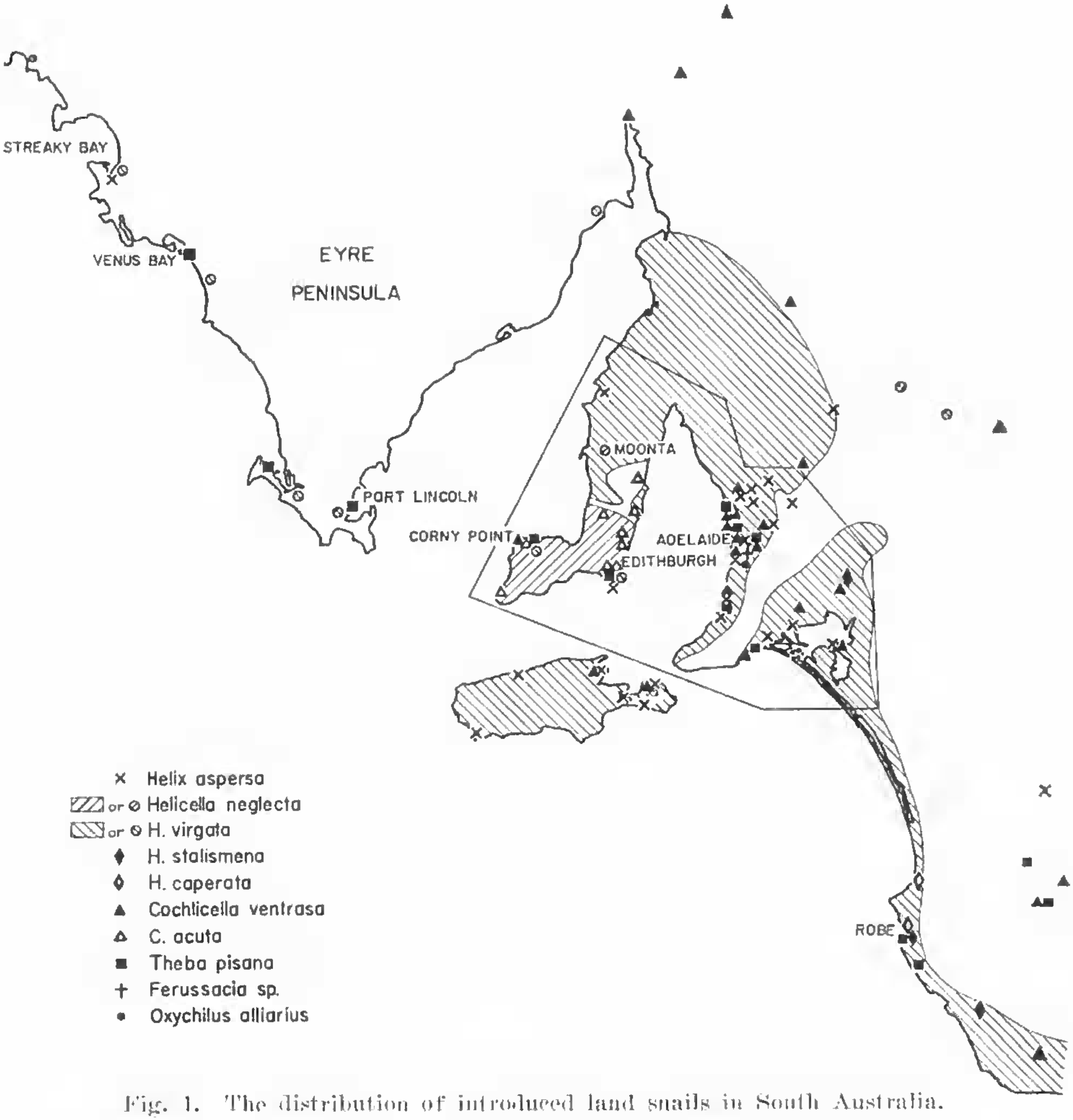

Fig. 1. The distribution of introduced land snails in South Australia.

It is likely that *Theba pisana* has reached its present distribution relatively rapidly over the past few years. Taylor (1928) recorded it from Outer Harbour, where it is at present plentiful, but the earliest South Australian collection of this species in the South Australian Museum is from Port Lincoln in 1956. All other distribution sites shown on fig. 1 have been established by the authors since 1962.

THE DISTRIBUTION OF *HELICELLA VIRGATA* AND *H. NEGLECTA*

Of the ten introduced species, *Helicella virgata* is the most widespread, its range in the State extending from Ceduna to the Victorian border. The main concentration is on the Adelaide Plains, adjacent areas of northern Yorke Peninsula, and the Lower Murray Valley. *H. neglecta* occurs on southern Yorke Peninsula. During summer these two species are easily observed on fence posts, telegraph poles, grass and shrubbery where they spend the dry months in a dormant state; in winter they are much less conspicuous. Because of this their distribution was studied during the summer.

Method of Survey.

Roadsides provide a favourable habitat for *Helicella* and also an easily accessible habitat where a large number of observations could be made in a relatively short time. The method used was as follows: a series of roads and tracks, parallel to each other and each about 5 miles from the next, was plotted on large-scale maps. Stops were made at 5-mile intervals along these routes and the abundance of snails estimated at each; about 600 sites were examined in this way. If no snails were found at a stopping-point, a continual watch was kept until they were found again to enable distribution boundaries to be established as accurately as possible.

Map of Distribution.

The survey included all the known range of *H. neglecta* and the main areas where *H. virgata* occurs. The results are shown in fig. 2, the extent of the survey and the overall distribution of *H. virgata* being given in fig. 1, along with distribution of other species. The remainder of the range of *H. virgata* was covered in much less detail by a series of transects along approximately 2,500 miles of main roads. This information, together with records from the Museum Collections, was used to determine the full extent of the distribution of *H. virgata* (fig. 1).

Figure 2 shows the relative densities of *H. virgata* and *neglecta* in different parts of their ranges. Five distribution ratings were used as follows:—

Rating 0: no snails found.

Rating 1: snails found at less than a quarter of the sampling-points.

Rating 2: areas where snails were found at between a quarter and a half of the sampling-points.

Rating 3: snails found at more than half of the sampling-points.

Rating 4: snails found at every sampling-point, and at a density of at least $20/m^2$ on both sides of the road at each sampling-point.

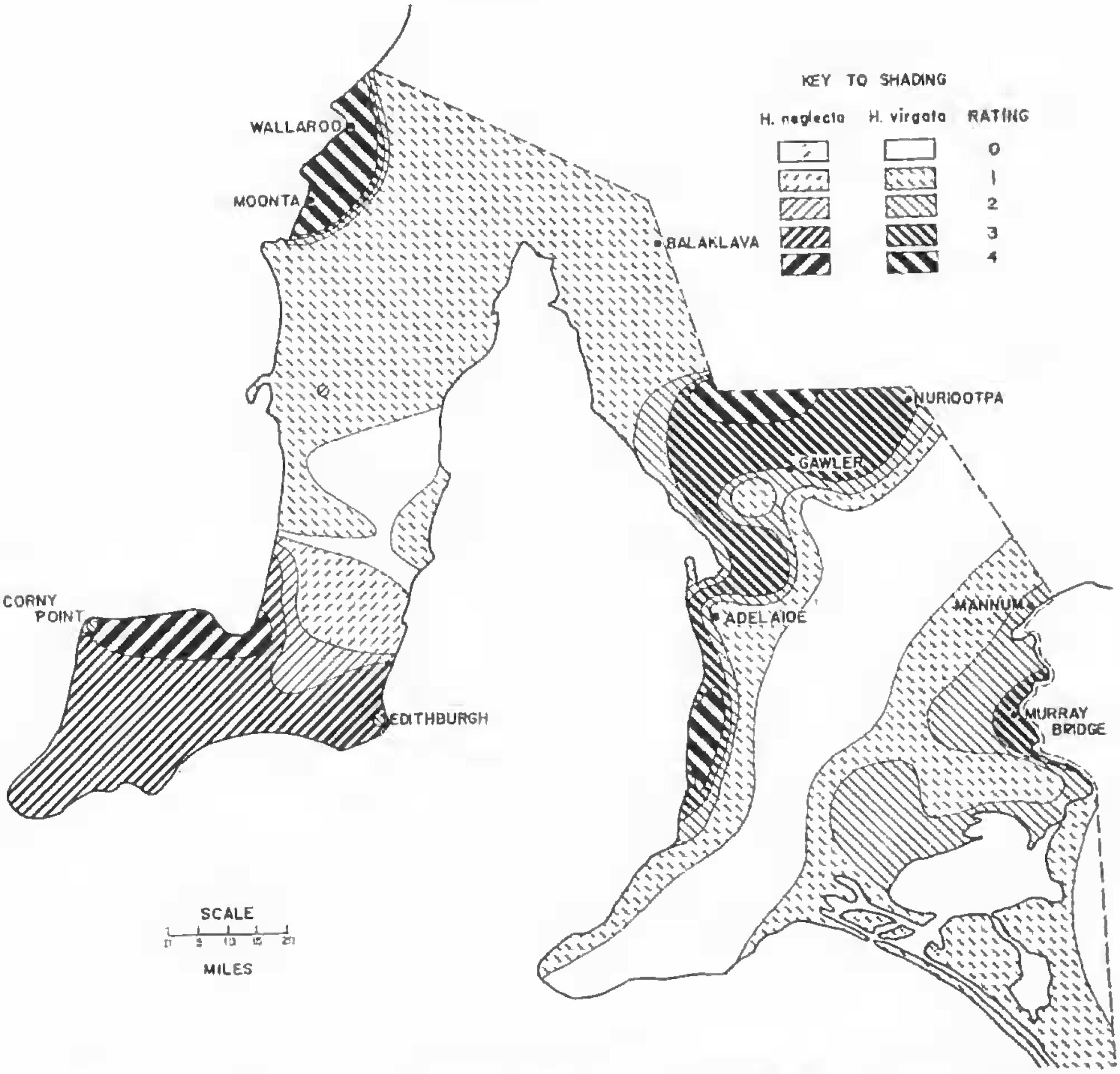

Fig. 2. The distribution and relative abundance of *Helicella virgata* and *H. neglecta.*

Since sampling-points were effectively random, fig. 2 indicates the probabilities of finding snails at any randomly selected roadside site within the area shown. The survey was, however, made in the summers of 1963-64 and 1964-65. Some changes in distribution will certainly occur from year to year and observations of marked yearly fluctuations have been made at a single site.

With the exception of three small colonies on Yorke Peninsula, the ranges of the two species do not overlap; they do, however, show a remarkable confrontation (fig. 2). It is also clear from the figure that *H. virgata* is relatively uncommon over most of its range.

The Spread of "H. virgata".

Although there is some evidence as to the time of arrival of this species in South Australia, there is almost no record of its spread from then to the present. There is, however, evidence that it is still spreading. On Eyre Peninsula its distribution is confined to coastal townships which are old ports. This, as well as a marked tendency to occur along major roads more frequently than minor ones, suggests a correlation with man's activities.

The most striking correspondence between the activities of man and the distribution of *H. virgata* is seen in the Mid-North of the State. Figure 3 shows the results of a survey in that region. Most snails are found near townships. In the northern part of the area no snails were found and this part may be unsuitable for them. In the southern parts of the area, snail distribution tends to join one township to the next. In the central part there are no occurrences of snails more than three or four miles from a township. Of the 37 townships shown in fig. 3, 19 are served by both a main road and a railway, six by a main road only, six by a railway only and six by neither. The presence or absence of snails at these townships is shown in table 3. The presence of a main road or railway seems to increase the likelihood of *H. virgata* becoming established. The null hypothesis that neither a main road nor a railway increases the probability of snails being present at a township can be tested. A 2X2 contingency test gives a value of Chi$_1^2$ = 4.82, after applying Yates' correction. The probability of this value arising by chance is about 0.03 and the null hypothesis may therefore be rejected.

TABLE 3

The relationship between transport routes and the presence of *Helicella virgata* in townships of the mid-north of South Australia

Transport Routes Serving Townships	Number of Townships	
	Snails Present	Snails Absent
Main road only	4	2
Railway only	3	3
Railway and main road	16	3
Neither railway nor main road	1	5

It is thus most likely that *H. virgata* has spread and is spreading by man's activities, in the Mid-North. Snails may reach outlying townships on vehicles and railway wagons which they have previously climbed during a dry spell. Rain will bring them down from their means of transport to become established as a new colony if conditions are favourable. Townships such as Burra, Spalding and Port Broughton are at this stage. Such a township then becomes a centre

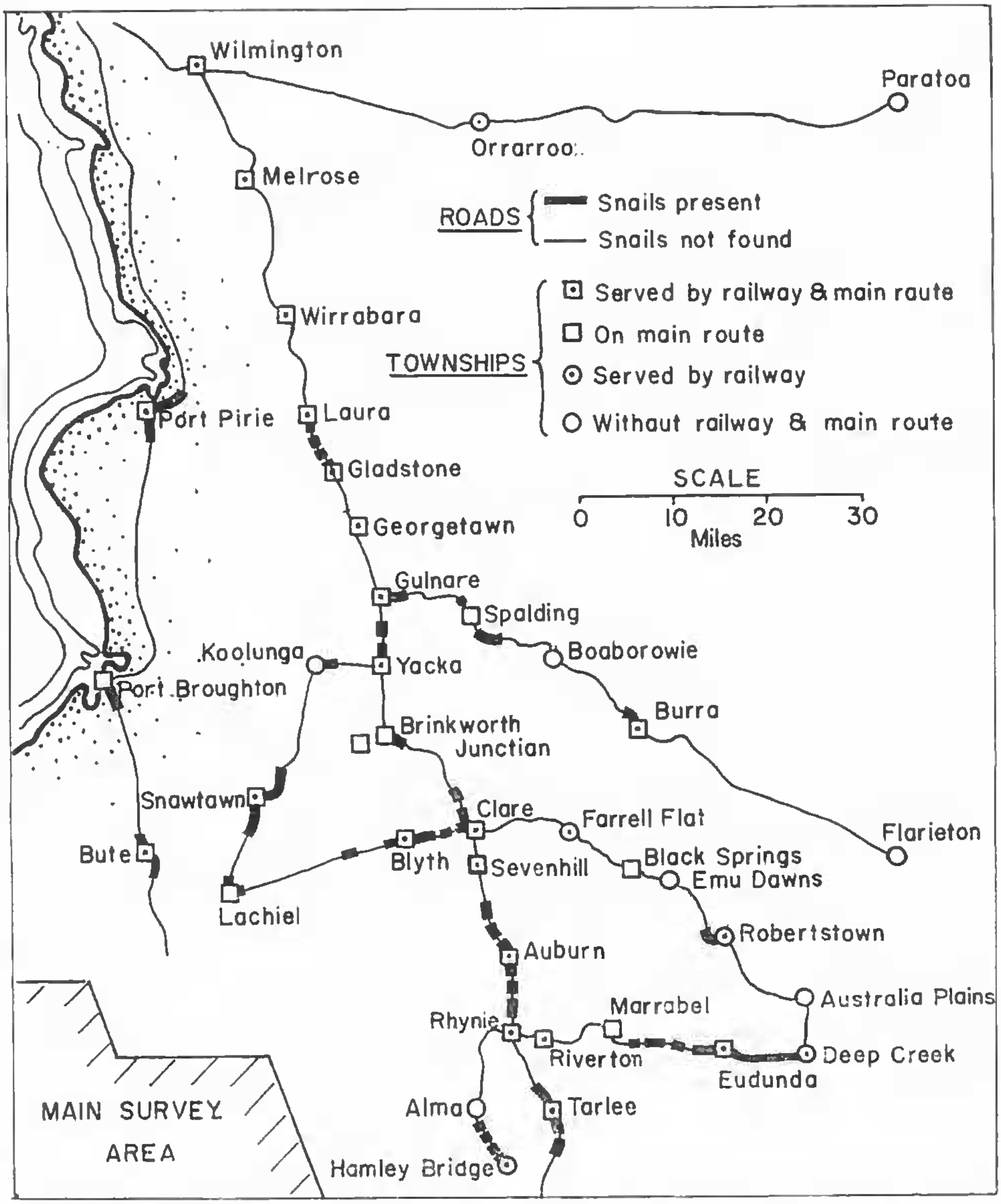

Fig. 3. The distribution in the Mid-North of South Australia of *Helicella virgata* in relation to transport routes.

for local dispersal particularly by farm vehicles, and subsidiary colonies may be started as around Clare, Rhynie and Eudunda. Eventually the colonies spread over all suitable country and coalesce as in most of the area shown in fig. 2. It seems clear that *H. virgata* is still spreading and it is probable that the spread will continue.

Relationships Between the Distribution of "H. virgata" and those of "H. neglecta" and of "Theba pisana".

Attention was earlier drawn to the confrontation in the distributions of *H. virgata* and *H. neglecta*. Many earlier records were based on mis-identification and are unreliable so that the sequence of events leading to the present situation is unknown. However, there are authentic records, based on South Australian Museum collections, of *H. neglecta* in the Moonta area, where it was apparently common earlier in the century, and where *H. virgata* is now abundant. Most early records for Yorke Peninsula seem to refer to *H. neglecta* and it is most likely that *H. virgata* has arrived more recently; *H. neglecta* was first recorded in the State much earlier than *H. virgata*. There is thus some evidence that the range of *H. neglecta* is contracting and considerable evidence that *H. virgata* is expanding its range but at present one can only speculate as to whether the two events are related.

In February, 1962, *H. virgata* was the dominant snail at Outer Harbour, a few miles north of Adelaide; in November of the same year *Theba pisana* appeared to be much more numerous. Four permanent quadrats were established there in August 1963, in an attempt to discover if these changes represented a continuous trend. Each quadrat was of 1 square metre and when first chosen, two were in areas where *H. virgata* was dominant, and two where *Theba* dominated. Only snails more than 5 mm. in diameter were recorded and quadrats were visited at approximately monthly intervals. Results for all four quadrats were similar and are shown in fig. 4; the proportions of *H. virgata* are also shown to facilitate comparisons.

T. pisana breeds later than *H. virgata*, its numbers reaching a peak several months after those of the latter species. The sizes of the large individuals of *T. pisana* were distributed bimodally, suggesting that the species takes two years to reach maximum size; *H. virgata* does so in one year. In spite of these complications, the overall numbers seem to show a trend in which *T. pisana* is increasing and *H. virgata* decreasing. In each case, where a comparison can be made between the two years, the population of *H. virgata* was lower in the second year.

H. virgata apparently does not eat green plants; *T. pisana* will, but the appearance of the Outer Harbour vegetation does not suggest heavy "grazing" and it is probably, like *H. virgata*, largely microphagous in its feeding habits. *T. pisana* may be superseding *H. virgata* by exploiting a limited resource—in this case, food—more effectively, and the observed changes in density could therefore be explained in terms of competition (in the restricted sense defined by Birch, 1957).

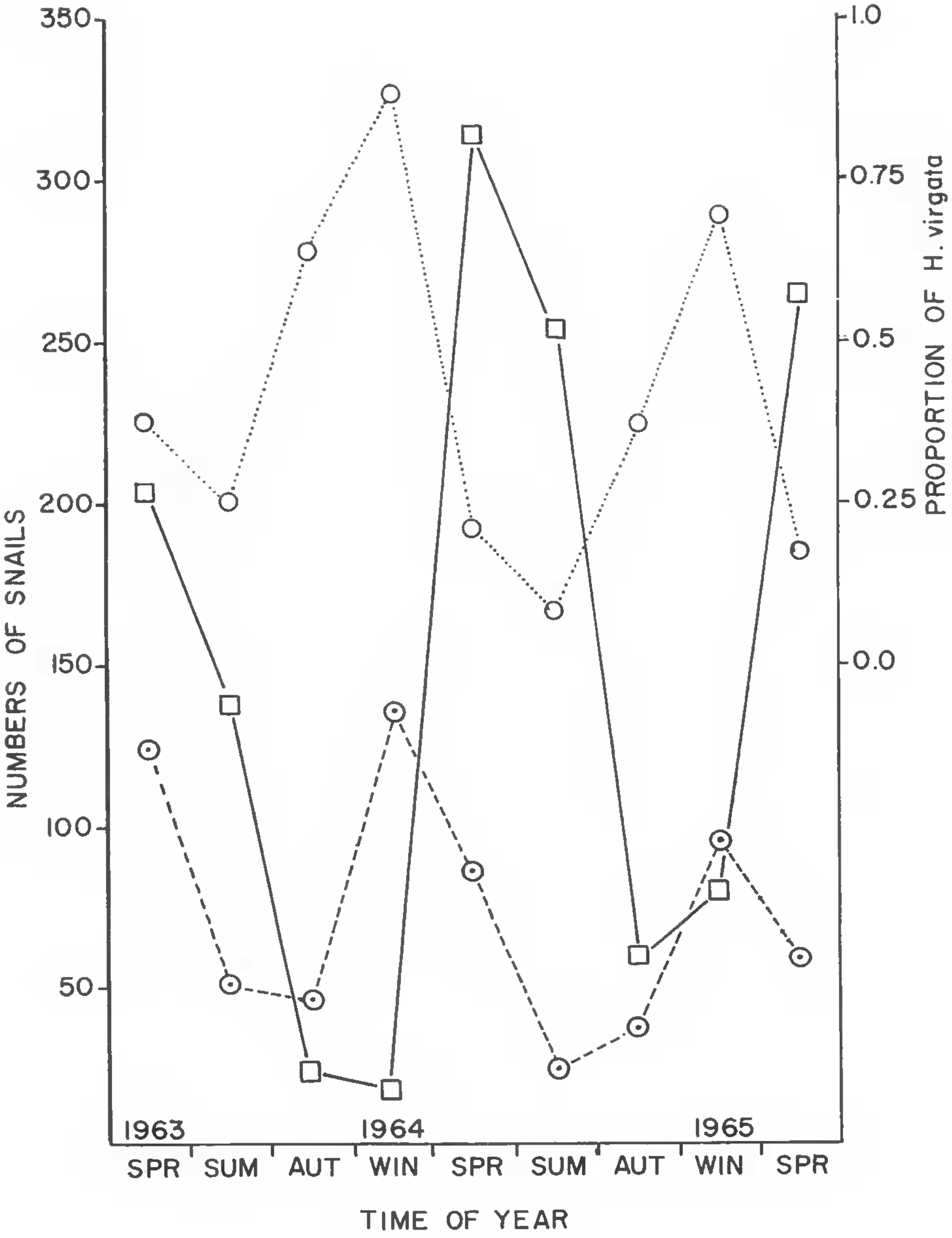

Fig. 4. Numbers of *Helicella virgata* and *Theba pisana* at Outer Harbour from 1963 to 1965. Numbers of *H. virgata*, ⊙ - - - ⊙; proportion of *H. virgata*, ○ . . . ○; numbers of *T. pisana*, □ —— □.

However, there is insufficient evidence at present for this explanation to be considered as more than tentative.

The next decade or two may show interesting changes in the distribution and abundance of *H. virgata, H. neglecta* and *T. pisana* in South Australia.

THE IMPORTANCE TO MAN OF INTRODUCED SNAILS IN SOUTH AUSTRALIA

The introduction of animals to areas where they are not native, often has serious economic results; man is, in most cases, the agent responsible for the introduction, either intentionally or not.

Helix aspersa has become a serious pest on five continents, but in South Australia its ravages have so far, been limited mainly to gardens. The fact that it appears unable to survive in this State except under conditions of summer watering, may mean that here it can only become a pest of irrigated crops and market gardens; control is relatively simple on this scale. *Theba pisana* is, as yet, of no economic importance in this State; at present it is found most usually in uncultivated areas and the largest colony is probably that at Outer Harbour which extends for about 10 km. down the coast towards Grange. The many thousands of dollars spent on eradicating it from California (Basinger, 1927), and the major attempts to control it in South Africa (S. S. Walters, pers. comm.), suggest that it could become a serious problem here, and should therefore be regarded with caution. The same may apply to *Cochlicella ventrosa,* a species which is much addicted to seedlings. Like *T. pisana,* it is capable of surviving warm dry summers and might well become a pest of improved pastures and legume crops, as has happened in parts of South Africa (S. S. Walters, pers. comm.).

Helicella virgata is relatively harmless. It has, however, sometimes been numerous enough around Moonta (fig. 2) to cause trouble on barley crops. Snails aestivating on the ears may be threshed with the grain and the effect of large numbers of pulverised snails can be sufficient to raise the moisture content of the grain above the level acceptable for bulk storage. Observations in the area suggest that the problem is largely confined to the edges of the paddocks. The number of snails per ear (which exceeded 20 in some cases) fell rapidly, and except in a few instances there were rarely snails more than 10 or 20 metres from the boundary. Farmers found, however, that a horizontal bar placed in front of the reaping arms, knocked off most of the snails without seriously damaging the crop. *H. neglecta* was, in a similar way, a serious pest to some of the barley growers in the southern part of Yorke Peninsula about 30 years ago but changes in agricultural practice have largely overcome the problem.

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SUMMARY

Ten species of land snail are known to have become established in South Australia. The present distribution of these species in the State and their probable time of arrival are discussed. Detailed study is made of the distribution of *Helicella virgata* which occurs through much of the agricultural regions of the State including Northern Yorke Peninsula, and *H. neglecta* which is found only on Southern Yorke Peninsula. It is concluded that *H. virgata* is still extending its range in the State and that it may be replacing *Theba pisana* at Outer Harbour. The problem of *Helicella virgata* aestivating on barley ears has been overcome, as has the same problem with *H. neglecta*. *Helix aspersa* is a pest of gardens with summer watering. *Theba pisana* and *Cochlicella ventrosa*, both of which are widespread in the State, are serious pests in other parts of the world and both should be regarded with caution in South Australia.